

Solar Collector Manufacturing Activity 1988



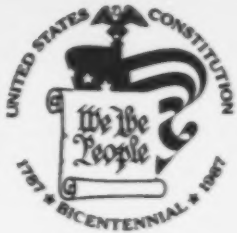
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Aerial view of the SEGS Plants in Kramer Junction, California.



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Solar Collector Manufacturing Activity 1988

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Electric and Alternate Fuels
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Preface

This report was prepared by the Energy Information Administration, the independent statistical and analytical agency within the U.S. Department of Energy in cooperation with the Office of Conservation and Renewable Energy. The report presents data on producer shipments and end uses obtained from manufacturers and importers of solar thermal collectors and photovoltaic modules. It provides annual data neces-

sary for the Department of Energy to execute its responsibility to (1) monitor activities and trends in the solar collector manufacturing industry, (2) prepare the national energy strategy, and (3) provide information on the size and status of the industry to interested groups such as the U.S. Congress, government agencies, the Solar Energy Research Institute, solar energy specialists, manufacturers, and the general public.

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Executive Summary

Introduction

This report presents a statistical profile of the solar collector manufacturing industry and the photovoltaic module manufacturing industry during 1988.

Solar Thermal Collector Manufacturing Activity for 1988

Shipments of solar thermal collectors in 1988 were reported by 50 firms, totaling 4.06 million square feet of collectors. Of these, approximately 814,000 square feet of collectors were imported and approximately 158,000 square feet were exported for use in other countries. Low-temperature collectors comprised approximately 82 percent of total shipments, with the remaining shipments comprising medium-temperature and special solar thermal collector types.

Solar thermal collector shipments (including exports and imports) declined from an average of 18 million square feet between 1980 and 1984 to 4 million square feet between 1986 and 1988. The decline began with the expiration of the 40-percent residential energy tax credit and the 15-percent business energy tax credit at the end of 1985.

Activity in 1988 is summarized below:

- Total shipments of solar thermal collectors were approximately the same in 1987 and 1988.
- Shipments of medium-temperature, special, and "other" types of collectors declined from 957,000 square feet in 1987 to approximately 732,000 square feet in 1988—a 24-percent decline.
- Shipments of low-temperature collectors, however, increased from 3.2 million square feet in 1987 to 3.3 million square feet in 1988, a 5-percent increase.

- The number of firms shipping solar thermal collectors decreased from 58 in 1987 to 50 in 1988.
- The average shipment per manufacturer of medium-temperature collectors decreased from 19,000 square feet in 1987 to 16,000 square feet in 1988. The average shipment per manufacturer of low-temperature collectors increased from 263,000 square feet to 416,000 square feet.
- Shipments by end use were dominated by pool-heating applications, which made up 81 percent of all shipments. Water-heating applications (excluding pool-heating) accounted for 18 percent of all shipments.
- Shipments by market sector were dominated by shipments to the residential sector, which accounted for 94 percent of all shipments.

Photovoltaic Module Manufacturing Activity for 1988

Photovoltaic module manufacturing activity for 1988 increased 41 percent from 1987. In 1988, there were shipments of 9,676 kilowatts by 14 companies, compared with 6,850 kilowatts by 17 firms in 1987.

The value of shipments in 1988 was approximately \$59 million, for an average of about \$6.10 per watt. By comparison, in 1987 the average price of photovoltaic modules was \$6.55 per watt, with a value of shipments of \$45 million.

Single-crystal silicon modules accounted for about 57 percent of all photovoltaic module shipments in 1988. The next most prevalent type of modules shipped was amorphous silicon, followed by cast- and ribbon-type.

The largest end use for photovoltaic shipments in 1988 was in residential applications, with 22 percent of the total, followed by communication applications with almost 21 percent of the total.

1. Introduction

This report presents data on producer shipments and end uses of solar thermal collectors and photovoltaic modules. The solar thermal collector manufacturing data are summarized for the 15-year period from 1974 through 1988, with detailed information presented for 1988. Appendix A explains the limitations of the 1985 survey.

Shipments of manufactured solar collectors are reported in square feet. In this report, shipment size refers to the area (in square feet) of solar thermal collec-

tors shipped, and to the amount (in peak kilowatts) of photovoltaic modules shipped. The 1988 data were collected on Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey," and Form CE-63B, "Annual Photovoltaic Module Manufacturers Survey." Appendix B contains copies of the survey forms and instructions. Appendices C and D list the solar thermal collector and photovoltaic module manufacturers, respectively, that responded to the 1988 survey and granted permission for their names and addresses to appear in the report.

2. Solar Thermal Collector Manufacturing

Industry Status

The solar thermal collector manufacturing industry continued its downward trend in volume of shipments and in number of active participants during 1988. The solar thermal collector market is continuing along the decline that became apparent in 1986. As Table 1 shows, the market was strong and growing from the mid-1970's to the early 1980's. The market remained strong through 1984. Although no survey was conducted during the year, 1985 appears to have been another good year (see Appendix A). However, solar collector shipments (including exports and imports) declined from an average of more than 18 million square feet between 1980 and 1984 to less than 5 million square feet in 1986, 1987, and 1988.

The decline began with the expiration of the 40-percent residential energy tax credit and the 15-percent business energy tax credit at the end of 1985, and intensified as oil prices plummeted in 1986. Retroactive reinstatement of the business energy tax credit in 1986, at the 15-percent level for 1986 and at 12 percent for 1987 and 1988, had little effect since the market for commercial solar systems had always been small.

The expiration of the residential energy tax credit appears to be the determining factor in the overall decline of the industry. This factor is cited in economic analyses of the industry and in the comments of respondents to the EIA survey. In response to the elimination of the tax credits, system prices have fallen somewhat but not enough to maintain the market for the relatively costly medium-temperature collectors used mainly for residential domestic water heating.

Table 1. Solar Thermal Collector Shipments, 1974-1988

Year	Number of Manufacturers Reporting Shipments	Number of Nonrespondents	Collector Shipments (thousand square feet)		
			Total Shipments	Imports	Exports
1988	50	0	4,059	814	158
1987	58	0	4,114	691	182
1986	97	0	4,862	473	224
1985 ^a	NA	NA	NA	NA	NA
1984	224	0	16,419	621	348
1983	203	21	^b 16,828	511	159
1982	265	9	^b 18,621	418	455
1981	203	79	^b 20,133	196	771
1980	233	43	^b 19,398	235	1,115
1979	349	0	14,251	290	855
1978	340	0	10,860	396	840
1977	321	0	10,312	NA	NA
1976	186	0	5,801	NA	NA
1975	131	0	3,743	NA	NA
1974	45	0	1,274	NA	NA

^a Incomplete data (see Appendix A).

^b Includes imputation for nonrespondents.

NA = Not available.

Sources: Energy Information Administration, "Annual Solar Thermal Collector Manufacturers Survey," 1974-1988 (Form CE-63A, 1935-1988; Form EIA-63, 1978-1984; telephone survey by the Federal Energy Administration, 1974-1977).

Table 2. Shipments of Solar Thermal Collectors by Collector Type, 1980-1988
(Thousand Square Feet)

Year/Data Source	Low-Temperature		Medium-Temperature ^a	
	Total Shipments	Average Annual Shipments per Manufacturer	Total Shipments	Average Annual Shipments per Manufacturer
1988 Reported	3,326	415.8	732	16.2
1987 Reported	3,157	263.1	957	19.1
1986 Reported	3,751	170.5	1,111	12.8
1985 ^b	NA	NA	NA	NA
1984 Reported	4,479	93.3	11,939	58.0
1983 Reported	3,526	—	11,678	—
Estimated	1,327	—	297	—
Total	4,853	88.2	11,975	66.9
1982 Reported	7,370	—	11,002	—
Estimated	106	—	143	—
Total	7,476	122.6	11,145	44.9
1981 Reported	8,339	—	10,023	—
Estimated	338	—	1,433	—
Total	8,677	115.7	11,456	43.6
1980 Reported	11,299	—	6,468	—
Estimated	934	—	697	—
Total	12,233	154.8	7,165	28.7

^a Includes medium-temperature, special (concentrator), and other solar thermal collector types.

^b Incomplete data (see Appendix A).

NA = Not available.

Sources: Energy Information Administration, "Annual Solar Thermal Collector Manufacturers Survey," 1980-1988 (Form CE-63A, 1985-1988; Form EIA-63, 1980-1984).

Some collectors can be bought for as little as \$40 per square foot (installed) but most are still in the range of \$55-80 per square foot.¹ The price for low-temperature collectors, used mostly for residential pool heating, is as little as 1/10 that of the medium-temperature collectors.² This price difference is one reason for the 90-percent decline in the market for medium-temperature collectors versus the 73-percent decline in the market for low-temperature collectors from 1980 through 1988 (Table 2).

Pool-heating collectors, which form the bulk of low-temperature collector shipments, never qualified for the Federal energy tax credit and thus were not adversely affected by its elimination. Also, pool-heating collectors are simpler and less technically demanding systems than medium-temperature collectors and thus suffer from comparatively few of the reliability problems that affect medium-temperature collectors. Low-temperature collectors are used for pool heating and provide a cost-effective alternative to electric heating in some regions.

¹Department of Energy, Office of Solar Heat Technology, "Solar Buildings Industry Update," Report by Science Applications International Corporation and Mueller Associates, Inc. under Contract DE-AC01-86CE30844, p. 4. Note that the cost data in the survey are for collector costs, not system costs. System costs include such items as the storage tank and installation. Typically, the system cost is two to three times the collector cost. These cost data are for flat-plate systems with relatively simple designs. Evacuated tube collectors, which operate at higher efficiencies, cost 50-100 percent more. Costs decline as system size increases for all types of units.

²Pool-heating systems typically have no storage tanks and require much less installation time and fewer materials than medium-temperature collectors for domestic water heating.

Between 1984 and 1987, the number of manufacturers or active industry participants declined dramatically, from 224 firms in 1984 to 58 in 1987 (Table 1). The number of active industry participants continued to decline through 1988, dropping slightly to 50 active manufacturers. The survey data indicate that the industry will likely continue to consolidate, because the majority of firms report low volumes of shipments.

The 1988 survey data indicate several notable changes in the industry. These are summarized below and are further discussed in the following sections.

- The number of solar thermal collector manufacturers decreased by eight participants, an indication that the industry consolidation is leveling off.
- Shipments of collectors decreased from 4.11 million square feet in 1987 to 4.06 million square feet in 1988, a decrease of only 1.3 percent.
- Shipments of collectors in the medium-temperature category decreased from 957,000 square feet in 1987 to approximately 732,000 square feet in 1988—a decrease of almost 24 percent.
- Shipments of low-temperature collectors, however, increased by approximately 5 percent, from 3.2 million square feet in 1987 to 3.3 million square feet in 1988.

Total Producer Shipments

In 1988, shipments of all types of solar thermal collectors totaled 4.06 million square feet (including imports), shipped by 50 manufacturers (Table 1). In 1987, 4.11 million square feet were shipped by 58 manufacturers.

The total volume of imports in 1988 was approximately 814,000 square feet, compared with approximately 691,000 square feet in 1987. The total volume of exports in 1988 was approximately 158,000 square feet, compared with about 182,000 square feet in 1987. The 1988 exports are the smallest reported since 1978, when export data were first collected.

Shipments of Medium- and Low-Temperature Collectors

In Table 2, the total shipments of solar thermal collectors are divided into two categories:

- Low-temperature collectors provide low-grade heat (less than 110 ° Fahrenheit) through either metallic or nonmetallic absorbers for applications such as swimming pool heating and low-grade water and space heating.

- Medium-temperature, special, and other collectors provide mid-to-high grade heat (greater than 110 ° Fahrenheit, usually 140–180 ° Fahrenheit), either through glazed flat-plate collectors using air or liquid as the heat transfer medium or through concentrator collectors that concentrate the heat to levels greater than "one sun." These include evacuated tube collectors.

In 1988, shipments of low-temperature and medium-temperature collectors totaled 3.3 million square feet and approximately 732,000 square feet, respectively, compared with 3.2 million square feet and 957,000 square feet, respectively, in 1987 (Table 2). The average annual shipment of low-temperature collectors per manufacturer was approximately 416,000 square feet in 1988, compared with approximately 263,000 square feet in 1987. The average annual shipment of medium-temperature collectors per manufacturer in 1988 was about 16,000 square feet, compared with 19,000 square feet in 1987. A company-by-company review of the shipment volumes shows that for low-temperature collector manufacturers, a small number of large manufacturers are increasing their market share in a relatively stable market at the expense of the smaller companies. In the case of medium-temperature collector shipments, a decreasing number of manufacturers are sharing in a more rapidly decreasing market. The smaller companies, many with clearly insufficient shipments to remain active, are continuing to leave the industry.

Industry Concentration

Of the 4.06 million square feet of thermal collectors shipped in 1988, 3.8 million square feet (93.8 percent) were manufactured and shipped by the 10 largest companies (Table 3). This compares with 3.7 million square feet out of a total of 4.1 million square feet (90.3 percent) shipped by the 10 largest companies in 1987. This shows a continuation of the industry concentration first observed in 1986.

The five largest companies were responsible for shipping approximately 3.5 million square feet, representing 85.5 percent of all shipments of solar thermal collectors. This compares with 78.2 percent in 1987, another sign of continued industry concentration.

Shipments of Collectors by State of Manufacture

Solar thermal collectors were reported to have been manufactured in 21 States and Puerto Rico. Because of possible disclosure problems, only the most active

Table 3. Shipments and Market Shares of the Ten Largest Manufacturers and Importers of Solar Thermal Collectors, 1982-1988

Year/ Company Rank	Solar Thermal Collectors Shipped (thousand square feet)	Percent of Industry Total
1988		
1-5	3,470	85.5
6-10	335	8.3
1-10	3,805	93.8
1987		
1-5	3,216	78.2
6-10	499	12.1
1-10	3,715	90.3
1986		
1-5	3,273	67.3
6-10	785	16.2
1-10	4,058	83.5
1985*	NA	NA
1984		
1-5	5,320	32.4
6-10	2,605	15.9
1-10	7,925	48.3
1983		
1-5	5,919	35.2
6-10	2,752	16.4
1-10	8,671	51.5
1982		
1-5	6,320	33.9
6-10	2,560	13.7
1-10	8,880	47.7

* Incomplete data (see Appendix A).

NA = Not available.

Source: Energy Information Administration, "Annual Solar Thermal Collector Manufacturers Survey," 1982-1988 (Form CE-63A, 1985-1988; Form EIA-63, 1982-1984).

States are listed in this report. As shown in Table 4, California was the largest producer, with 1.85 million square feet, followed by New York with approximately 0.88 million square feet, and Puerto Rico with approximately 0.28 million square feet. Of the 21 States, 8 had shipments of less than 1,000 square feet, and 8 had shipments between 1,000 and 10,000 square feet. No collector manufacturing activity was reported for 29 States, the Virgin Islands, and the District of Columbia.

Shipments of Collectors by State of Destination

Shipments of solar thermal collectors were reported to have been made to 40 States, Puerto Rico, and the Virgin Islands (Table 5). According to the survey, 10 States (Alaska, Idaho, Louisiana, Mississippi, North Dakota, Rhode Island, South Carolina, South Dakota, West Virginia, and Wyoming) and the District of Columbia did not receive collector shipments in 1988. Of the 40 States, 6 received negligible amounts of less

than 100 square feet, 16 States received shipments between 100 and 1,000 square feet, and 10 States/Territory received shipments between 1,000 and 10,000 square feet.

The States/Territory that received the largest total shipments of solar thermal collectors were: Florida, California, Puerto Rico, Arizona, and Hawaii (Tables 5 and 6). Florida received more than 1.90 million square feet of collectors, about 47 percent of all collector shipments, but manufactured less than 5 percent of all collectors shipped for U.S. consumption (exports excluded). California received 36 percent, the second largest share. Florida and California account for 85 percent of all collector shipments by State of destination (exports excluded) while Puerto Rico, Arizona, and Hawaii represent an additional 11 percent. In summary, these five States/Territory received 96 percent of all collector shipments bound for U.S. markets. The factors that these five States have in common are good solar insolation, high electricity costs, and strong demand for low-technology pool heaters.

Table 4. Top Three States/Territory of Solar Thermal Collector Manufacturing, 1988

Rank/State or Territory	Total Shipments (thousand square feet)	Percent of Total U.S. Manufacturing
1. California	1,851	57
2. New York	883	27
3. Puerto Rico	282	9
Total	3,016	93

Note: Totals may not equal sum of components because of independent rounding. Imports excluded.

Source: Energy Information Administration, "Annual Solar Thermal Collector Manufacturers Survey," Form CE-63A, 1988.

Interestingly, while Florida and California are by far the largest markets for solar thermal collectors, Florida is a large net importer of collectors from other States while California is a large net exporter to other States (Tables 4 and 6). New York is also a large net exporter to other States.

Shipments by End Use

Shipments of solar thermal collectors by type and eight categories of end use are presented in Table 7.

During 1988, shipments continued to be concentrated on pool-heating systems, which are generally low-technology designs. A common pool-heating collector is a black plastic or rubber-like sheet where the water circulates through tubing in the sheet or is sandwiched between layers of absorbing material. The heat of the sun is directly transferred from the black absorbing material to the water circulating throughout it. These systems may use a small pump or may be thermosiphon designs, in which the temperature gradient in the solar-heated water and cool pool water induces a flow and supplies heated water to the pool. Designs of this type are often termed passive collectors, as opposed to active collectors, which require some type of pump to

**Table 5. Destinations of Solar Collector Shipments by State or Territory, 1988
(Square Feet)**

Destination	Total Shipments	Destination	Total Shipments
Alaska	0	Nevada	6,856
Alabama	302	New Hampshire	541
Arizona	111,623	New Jersey	30,604
Arkansas	603	New Mexico	10,714
California	1,414,105	New York	72
Colorado	9,914	North Carolina	3,073
Connecticut	781	North Dakota	0
Delaware	120	Ohio	348
District of Columbia	0	Oklahoma	34
Florida	1,905,047	Oregon	18,600
Georgia	2,582	Pennsylvania	2,878
Hawaii	31,836	Puerto Rico	288,751
Idaho	0	Rhode Island	0
Illinois	613	South Carolina	0
Indiana	97	South Dakota	0
Iowa	192	Tennessee	177
Kansas	8,184	Texas	16,589
Kentucky	204	Utah	550
Louisiana	0	Vermont	417
Maine	13,167	Virgin Islands	5,505
Maryland	320	Virginia	1,875
Massachusetts	4,549	Washington	128
Michigan	8,270	West Virginia	0
Minnesota	61	Wisconsin	72
Mississippi	0	Wyoming	0
Missouri	64		
Montana	302	U.S. Total	3,901,135
Nebraska	415	Exports	157,686
		Total Shipments	4,058,821

Note: Totals may not equal sum of components because of independent rounding.

Source: Energy Information Administration, "Annual Solar Thermal Collector Manufacturers Survey," Form CE-63A, 1988.

Table 6. Top Five States/Territory Ranked by Destination of Solar Thermal Collector Shipments, 1988

Rank/State of Destination	Total Shipments (thousand square feet)	Percent of Total U.S. Shipments*
1. Florida	1,905	49
2. California	1,414	36
3. Puerto Rico	289	7
4. Arizona	112	3
5. Hawaii	32	1
Total	3,751	96

* Exports excluded.

Note: Totals may not equal sum of components because of independent rounding.

Source: Energy Information Administration, "Annual Solar Thermal Collector Manufacturers Survey," Form CE-63A, 1988.

circulate the water. The survey does not distinguish between active and passive low-temperature collectors.

Following pool heating, the second largest market is for water heating. Most of the water-heating market is supplied by two kinds of systems--medium-temperature thermosiphon or active flat-plate collector systems. Pool heating and water heating together account for 99 percent of the market (Table 7). Approximately 94 percent of the market is residential (Table 8). The nearly complete dominance of the residential market for pool heating and water heating has been a feature of the solar thermal collector market since its earliest days.

Typical domestic water-heating systems for single-family residences feature from two to four collectors (40-80 square feet) and provide 30-80 percent of the total water-heating requirements. Unlike a pool-heating system, a domestic water-heating system virtually always has a conventional backup (for example, gas or electric).

Two main technologies are used in the medium-temperature collector systems. The active flat-plate designs use a pump to circulate water through the collector and tank. A smaller percentage of the systems use a thermosiphon design, where the temperature gradient in the water induces circulation without a pump. Other systems represent a small percentage of the market. The collector itself is ordinarily a glass-covered metal box with a heat-absorbing material (for example,

Table 7. Shipments of Solar Thermal Collectors by Type and End Use, 1988
(Square Feet)

(Square Feet)

End Use	Low Temperature (Liquid and Air)	Medium Temperature					Special	Other	Total
		Air	Liquid						
			Medium Temperature	Thermosiphon	Flat Plate (pumped)	Integral Collector Storage	Evacuated Tube		
Pool Heating	3,276,151	0	0	25,458	0	0	0	0	3,303,609
Water Heating	48,301	53,452	292,528	278,248	53,492	70	84	0	726,175
Space Heating	0	6,680	0	0	0	0	84	0	6,744
Combined Space and Water Heating	0	0	0	11,007	0	4,176	0	0	15,183
Space Cooling	0	0	2,000	0	0	180	0	0	2,180
Process Heating ...	0	0	0	W	0	0	0	0	W
Electricity Generation	0	0	2,050	0	0	0	1,500	0	3,550
Other	0	0	0	W	0	0	0	0	W
Total	3,326,452	60,132	296,578	316,093	53,492	4,426	1,648	0	4,058,821

W = Withheld to avoid disclosure of individual company data.

Source: Energy Information Administration, "Annual Solar Thermal Collector Manufacturers Survey," Form CE-63A, 1988.

nonreflective, black coated copper) used to capture the solar radiation and transfer the heat to water flowing through the absorber.

Shipments to the remaining end-use categories are very small, as enumerated below:

- Space heating shipments totaled about 6,744 square feet, or less than 0.2 percent of total shipments.
- Combined space and water heating accounted for approximately 15,183 square feet, or 0.4 percent of total shipments.
- Space cooling, process heating, and electricity generation shipments accounted for 7,110 square feet, also less than 0.2 percent of total shipments.

Shipments by Market Sector

Shipment data for 1988 by market-sector categories and by collector type are provided in Table 8. The largest proportion of solar thermal collectors were shipped to the residential sector in 1987 and 1988, at approximately 3.8 million square feet in each year. Most of these were low-temperature metallic and non-metallic collectors for pool-heating applications, followed by thermosiphon and flat-plate pumped medium-temperature collectors for water heating.

Shipments to the commercial sector showed a decline from about 305,000 square feet in 1987 to approximately 255,000 square feet in 1988. The commercial sector generally comprises a large number of small applications, mostly pool heating for hotels, motels, and spas. The water-heating applications are generally for laundries, hotels, and other users of medium-temperature

water. Over the past few years, the commercial market for solar collectors has declined to a fraction of its previous size.

Shipments to the industrial sector declined from approximately 11,000 square feet in 1987 to less than 7,000 square feet in 1988. The data indicate that all the shipments were in the medium-temperature categories and were probably used for water or space heating.

Value of Shipments

The total value of solar thermal collector shipments in 1988 is reported in Table 9. The cost data provided in Table 9 represent the total value received for the collectors only, at the company's net billing price, freight-on-board at the factory. Low-temperature liquid and air collectors account for the highest total value in 1988 at \$7.4 million in shipments at an average price of \$2.24 per square foot. Flat-plate collectors ranked second, with \$5.9 million, averaging \$18.71 per square foot. Thermosiphon collectors ranked third, with almost \$3.4 million, at an average price of \$11.34 per square foot.

Despite the reduction of the market share for medium-temperature collectors to approximately 18 percent by square footage (including concentrator and "other" collectors), they still represent 60 percent of the market by value (Table 9). The reason is the difference in system configuration, materials and design, between the low- and medium-temperature collectors.

Table 8. Shipments of Solar Thermal Collectors by Type and Market Sector, 1988
(Square Feet)

(Square Feet)									
Market Sector	Low Temperature (Liquid and Air)	Medium Temperature					Special	Other	Total
	Metallic and Nonmetallic	Air	Liquid				Concentrator		
		Medium Temperature	Thermosiphon	Flat Plate (pumped)	Integral Collector Storage	Evacuated Tube			
Residential	3,116,427	51,748	293,622	276,053	53,472	4,176	148	0	3,795,646
Commercial	210,025	8,384	2,956	33,375	W	0	W	W	254,760
Industrial	0	0	0	6,665	0	0	0	0	6,665
Utility	0	0	0	0	W	180	1,500	W	1,680
Other	0	0	0	0	0	70	0	0	70
Total	3,326,452	60,132	296,578	316,093	53,492	4,426	W	W	4,058,821

W = Withheld to avoid disclosure of individual company data.

Source: Energy Information Administration, "Annual Solar Thermal Collector Manufacturers Survey," Form CE-63A, 1988.

Table 9. Value of Shipments and Average Value of Solar Thermal Collectors, 1988

Collector Type	Value of Shipments (dollars)	Average Value (dollars per square foot)
Low Temperature		
Liquid and Air	7,448,172	2.24
Medium Temperature		
Air	525,908	8.75
Thermosiphon	3,363,719	11.34
Flat Plate	5,914,600	18.71
Integral Collector Storage	940,080	17.57
Evacuated Tube	124,428	28.11
Special		
Concentrator	207,000	125.61
Other	0	—
Total	18,523,907	4.56

Note: Total may not equal sum of components because of independent rounding.

Source: Energy Information Administration, "Annual Solar Thermal Collector Manufacturers Survey," Form CE-63A, 1988.

Imports

Imports of solar thermal collectors in 1988 totaled about 814,000 square feet, an increase of 18 percent from approximately 691,000 square feet of imports reported in 1987 (Table 1). In 1988, imports accounted for 20 percent of total collector shipments, an increase from the 17 percent reported in 1987. Approximately 784,000 square feet of the imported collectors were low-temperature collectors, followed by approximately 25,000 square feet of the medium-temperature thermosiphon type. During 1988, five companies reported imports of solar thermal collectors from four countries: Australia, Canada, Israel, and the United Kingdom (Table 10). Of these five companies, two were exclusively importers and three were both manufacturers and importers.

Exports

Exports of solar thermal collectors totaled approximately 158,000 square feet, or approximately 4 percent of all the collectors shipped in 1988 (Table 1). In 1988, about 65,000 square feet of exported collectors were of the low-temperature type. Exports of solar thermal collectors were reported by 12 companies to 23 countries, 1 territory, and 1 general area (Table 10). The distribution of exports by country of destination is not reported by the survey.

Related Activities

The 50 companies reporting shipments of solar collectors in 1988 also reported being engaged in one or more of the following activities: collector or system design (30), prototype development (15), prototype systems development (11), wholesale distribution (31),

Table 10. Origin of U.S. Imports and Destination of U.S. Exports of Solar Thermal Collectors, 1988

Origin of Imports	Destination of Exports		
Australia	Antigua	Columbia	Republic of Korea
Canada	Australia	Guatemala	St. Kitts
Israel	Bahamas	India	Saudi Arabia
United Kingdom	Barbados	Japan	Southeast Asia
	Bermuda	Jordan	Taiwan
	Bolivia	Lebanon	Turks and Caicos Islands
	British Virgin Islands	Mexico	United States Virgin Islands
	Canada	Montserrat	West Indies
	Chile		

Source: Energy Information Administration, "Annual Solar Thermal Collector Manufacturers Survey," Form CE-63A, 1988.

retail distribution (22), and installation (19). Table 11 shows the related activities reported by manufacturers of solar thermal collectors for 1986 through 1988.

Table 12 shows the distribution of firms by solar-related sales volume categories. For most solar thermal collector manufacturers (54 percent of the respondents), solar-related sales volume represented 90 to 100 percent of their sales. For 18 percent of the reporting manufacturers, solar-related sales volume represented 50 to 89 percent of the sales. Therefore, solar-related sales dominated total sales for more than two-thirds of all manufacturers; 8 percent of the manufacturers reported that solar-related sales represented between 10 and 49 percent of total sales volume, and 20 percent of the firms reported that solar sales represented less than 10 percent of their total revenue.

Some solar-collector manufacturing firms indicated that they planned to introduce new products in 1989.

Five manufacturers intended solar-related expansions in the medium-temperature collector category, while one manufacturer targeted the special-collector category (Table 13). There were no plans by any manufacturer to introduce new low-temperature collectors in 1989.

Employment

The 50 active firms reported a total of 355 full-time equivalent employees in solar-related activities. Of the 50 manufacturers reporting shipments of solar collectors in 1988, 23 companies reported having 2 or fewer employees in solar-related activities. Forty-two manufacturers, or approximately 84 percent, had ten or fewer full-time equivalent employees contributing to solar-related activities.

Table 11. Related Activities Reported by Manufacturers and Importers of Solar Thermal Collectors, 1986-1988

Type of Activity	Number of Manufacturers Engaged in Activity		
	1988	1987	1986
Wholesale Distribution	31	36	70
Retail Distribution	22	27	45
Collector or System Design	30	35	52
Installation	19	26	36
Noncollector System Components Manufacture	19	14	26
Prototype Collector Development	15	17	23
Prototype Systems Development	11	10	19

Source: Energy Information Administration, "Annual Solar Thermal Collector Manufacturers Survey," Form CE-63A, 1986-1988.

Table 12. Distribution of Solar Thermal Collector Manufacturers and Importers by Solar-Related Sales Volume as a Percentage of Total Sales Volume, 1988

Solar-Related Sales Volume as a Percent of Total Sales Volume	Percent of Manufacturers
90-100	54
50-89	18
10-49	8
Less than 10	20
Total	100

Source: Energy Information Administration, "Annual Solar Thermal Collector Manufacturers Survey," Form CE-63A, 1988.

**Table 13. Number of Solar Thermal Manufacturers Expecting
to Introduce New Solar-Related Products in 1989**

New Product Category	Number of Manufacturers
Low-Temperature Collector	0
Medium-Temperature Collector	5
Special Collector	1
Noncollector Solar System Components	2
Other	4

Source: Energy Information Administration, "Annual Solar Thermal Collector Manufacturers Survey," Form CE-63A, 1988.

3. Photovoltaic Module Manufacturing

This chapter presents information on the status of the photovoltaic (PV) manufacturing industry in 1988, and includes: (1) an accounting of the number of companies that manufactured and shipped photovoltaic (PV) modules; (2) total producer shipments, both aggregated and delineated by end use; (3) total PV module exports and imports; and (4) present and potential near-term, PV-related activities. Since the end-use categories and module type classifications for the survey were updated and redefined to reflect the current industry, only aggregate totals are compared with results from previous years.

Modules are defined as PV cells assembled into panels (modules). Modules are shipped either for final consumption or to another organization for resale. Cells are defined as the unencapsulated semiconductor components of the module. PV cells (not including incomplete cells) convert the solar energy to electricity. The domestic shipments do not include cells, but only shipments of the final products--modules. Data on PV module shipments presented in this report represent modules manufactured and shipped by U.S. manufacturers for domestic use and for export, as well as imported modules and unencapsulated PV cells exported to other countries. This allows for an accounting of all PV module-related manufacturing in the United States.

Photovoltaic Module Manufacturers

The number of companies that manufacture and sell PV modules declined from 17 in 1987 to 14 in 1988. The total amount of PV modules shipped was 9,676 peak kilowatts, an increase of 41 percent over 1987 shipments (Table 14).

Value of Shipments

The total value for shipments of PV modules was approximately \$59.1 million in 1988 and the average value was \$6.10 per peak watt (Wp) (Table 15). The figures were \$45.0 million (\$6.55/Wp) and \$38.1 million (\$6.01/Wp) in 1987 and 1986, respectively. Single-crystal silicon, the primary cell type, is also the least costly at \$4.19/Wp. At these prices, PV modules are cost-effective in certain remote and small-power applications, including communications. While these prices have declined sharply over the past decade, it is estimated that module costs of less than about \$1.50/Wp will be necessary for photovoltaics to compete with conventional fossil fuels for generating electricity by utilities. As the price of PV modules declines towards that level, other applications could open up and the market for PV modules could expand.

Table 14. Annual Photovoltaic Module Manufacturing Activity, 1982-1988

Year	Amount Shipped (peak kilowatts)	Number of Active Companies
1988*	9,676	14
1987*	6,850	17
1986*	6,333	17
1985*	5,769	15
1984	9,912	23
1983	12,620	18
1982	6,897	19

* Does not include shipments of modules for space satellite applications.

Sources: Energy Information Administration, "Annual Photovoltaic Module Manufacturers Survey," Form EIA-63, 1982-1984; Form CE-63B, 1985-1988.

Table 15. Value of Shipments and Average Value of Photovoltaic Modules by Type, 1988 and 1987

Collector Type	Value of Shipments (dollars)		Average Value (dollars per peak watt)	
	1988	1987	1988	1987
Crystalline Silicon				
Single-Crystal	23,065,216	21,094,416	4.19	5.37
Cast and Ribbon	14,346,237	15,414,500	7.73	9.13
Thin Film Amorphous Silicon	18,310,611	8,234,676	9.66	6.69
Concentrator Silicon	10,000	R91,833	10.00	R13.71
Other	3,333,000	—	8.01	—
Total	59,065,064	R44,835,425	6.10	R6.55

* This table does not include shipments of modules for space satellite applications.

R = Revised data.

Source: Energy Information Administration, "Annual Photovoltaic Module Manufacturers Survey," Form CE-63B, 1987-1988.

Table 16. Annual Photovoltaic Module Shipments by Module Type, 1988 and 1987

Module Type	Amount Shipped (peak kilowatts)		Percent of Total	
	1988	1987	1988	1987
Crystalline Silicon				
Single-Crystal	5,508	3,925	56.9	57.2
Cast and Ribbon	1,856	1,668	19.2	24.6
Thin Film Amorphous Silicon	1,895	1,230	19.6	17.9
Concentrator Silicon	1	R7	0.01	0.2
Other	416	—	4.3	—
Total*	9,676	R6,850	100.0	100.0

* Totals may not equal sum of components because of independent rounding.

R = Revised data.

Note: This table does not include shipments of modules for space satellite applications.

Source: Energy Information Administration, "Annual Photovoltaic Module Manufacturers Survey," Form CE-63B, 1987-1988.

Total Producer Shipments

Table 16 shows module shipments by type of module for 1987 and 1988. Single-crystal silicon modules continue to be the most widely manufactured type, accounting for 5.5 megawatts (peak) or about 57 percent of U.S. shipments. Thin-film amorphous silicon modules accounted for almost 1.9 megawatts (peak) or almost 20 percent, and cast- and ribbon-type modules accounted for almost 1.9 megawatts (peak) or about 19 percent of total shipments.

Shipments by End Use

Residential (22 percent), consumer goods (18 percent), and communication (21 percent) are the most important end uses (Table 17). Much of the other usage is for commercial/industrial applications and for activities such as battery charging, refrigeration, and water pumping in areas not connected to an electric grid. Few PV applications are used in competition with conventional grid-connected electricity. The most notable shift between 1987 and 1988 is the expansion of the consumer goods and communication categories of end use. The consumer goods category includes but is not limited to calculators, watches, and residential lighting.

Table 17. Photovoltaic Module Shipments by End Use, 1988 and 1987

End Use	Amount Shipped (peak kilowatts)		Percent of Total	
	1988	1987	1988	1987
Water Pumping	655	438	6.8	6.4
Transportation	435	322	4.5	4.5
Communication	2,024	1,319	20.9	19.2
Consumer Goods	1,747	793	18.1	11.6
Military	122	W	1.3	W
Residential	2,139	1,745	22.1	25.5
Industrial/Commercial	1,584	1,413	16.4	20.6
Utility	699	534	7.2	7.8
Other	272	W	2.8	W
Total ^a	9,676	6,856	100.0	100.0

^a Totals may not equal sum of components because of independent rounding.

W = Withheld to avoid disclosure of individual company data.

Source: Energy Information Administration, "Annual Photovoltaic Module Manufacturers Survey," Form CE-63B, 1987-1988.

Exports and Imports

Photovoltaic module manufacturers exported 5,358 kilowatts of PV modules and cells in 1988, compared with 1987 exports of 3,821 kilowatts. Exports in 1988 represented more than 55 percent of all shipments. This is similar to 1987 when exports represented approximately 60 percent of shipments. Of the 5,358 kilowatts exported in 1988, modules comprised 4,276 kilowatts (80 percent) and cells comprised 1,082 kilowatts (20 percent). The predominant type of PV module and cell exported were single-crystal silicon devices. Cast-silicon modules were the second most popular PV modules exported during 1988, followed by amorphous silicon and negligible amounts of the other types of modules.

In 1988, five companies imported 1,453 kilowatts of PV modules. Only two types were imported: amor-

phous silicon and single crystal silicon. The countries of origin of imported modules were Australia, France, Japan, and the United Kingdom.

Technology Status and Photovoltaic Industry Plans

Table 18 presents the number of companies planning to introduce new PV-related products in 1989, as indicated by data from survey year 1988. Table 19 provides the number of manufacturers involved in various PV-related activities during 1987 and 1988. With the exception of module or system design and installation, 1988 participation levels remained nearly the same as for 1987.

Table 18. Number of Photovoltaic Module Manufacturers Expecting to Introduce New Photovoltaic-Related Products Within Year of Survey

Type of Product	Number of Manufacturers	
	Survey Year 1988	Survey Year 1987
Single-Crystal Silicon Modules	3	2
Cast Silicon Modules	3	4
Ribbon Silicon Modules	1	1
Amorphous Silicon Modules	4	3
Other (Flat Plate)	2	1
Other (Concentrator)	2	4
Nonmodule System Components	3	5

Source: Energy Information Administration, "Annual Photovoltaic Module Manufacturers Survey," Form CE-63B, 1987-1988.

**Table 19. Number of Photovoltaic Module Manufacturers Involved
in Photovoltaic-Related Activities, 1988 and 1987**

Type of Activity	Number of Manufacturers	
	1988	1987
Module or System Design	12	16
Prototype Module Development	11	13
Prototype Systems Development	8	9
Wholesale Distribution of Modules	8	9
Retail Distribution of Modules	9	9
Installation	5	8
Nonmodule System Component Manufacture	4	5
Other	3	2

Source: Energy Information Administration, "Annual Photovoltaic Module Manufacturers Survey," Form CE-63B, 1987-1988.

4. History and Methodology of the Survey

History of the Survey

The Energy Information Administration (EIA) and its precursor organizations began conducting voluntary telephone surveys of manufacturers of solar thermal collectors in 1975. The goal of these surveys was to obtain information on manufacturing activity in the solar industry. The first survey covered manufacturing activity for 1974. Succeeding surveys were conducted every 6 months to inform both public and private interests of trends in this industry. The mandatory reporting of data under Public Law 93-275 began with the survey period covering July through December of 1978. Beginning in 1982, the survey was administered annually rather than semiannually.

Methodology of the Survey

General Procedures

The solar thermal collector (Form CE-63A) and photovoltaic module (Form CE-63B) manufacturer survey forms cover a 12-month period, from January through December of each calendar year. (Appendix B gives a copy of the survey forms.) The 1988 survey was sent out via certified mail in early 1989.

Survey questions are designed to elicit data on company shipments, manufacturing, importing, exporting, and related activities. Care has been taken to establish the survey frame accurately. However, because the solar collector manufacturing industry is subject to sporadic entry and exit of manufacturers, the frame of this survey may exclude some of the manufacturers who entered the industry after 1984--particularly in 1985 (a year in which the survey was not conducted).

Manufacturers of solar thermal collectors were requested to report their annual shipments in terms of square feet of collectors shipped whether manufactured or imported. Surveyed companies were also requested to indicate prototype development, note other related activities in which they were engaged, and provide information concerning market sector and end-use

breakdowns, as well as information on company size. All appropriate data were disaggregated by type of solar collector. Manufacturers of photovoltaic modules were asked to provide similar data indicating production in terms of electrical capacity expressed in peak kilowatts.

Follow-up procedures were carried out to reduce the nonresponse rate and possible resulting bias. Follow-up procedures consisted of (1) re-sending surveys to companies with new addresses, (2) reminder calls to all companies that did not return completed survey forms within the 1-month period specified in the cover letter, and (3) additional calls to companies that did not respond within a few weeks of the first round of calls. During the second round of calls, data were taken over the telephone whenever possible. Data received over the phone were entered on a blank survey form, which was then returned to the company for verification and appropriate signatures.

Responses to the surveys were first edited manually to verify the accuracy of the reporting and to ensure reliability of the data. Selected individual company responses were also compared with the data reported in previous surveys. Wherever manual editing procedures indicated discrepancies or omissions, telephone calls were made to confirm and/or clarify the data. Data from manually edited forms were then entered into a computer and edited a second time via an automated procedure.

Survey Format

In 1985, the solar manufacturers questionnaire was modified to give more useful information than the previous survey form (EIA-63). The modifications included devising two separate forms: one for solar thermal collector manufacturers (Form CE-63A), and the other for photovoltaic module manufacturers (Form CE-63B). The modifications affecting both forms and each form individually are outlined below:

Modifications Affecting Both Survey Forms:

- Information on the respondent's company type (partnership, corporation, or single proprietorship) was not included in the new questionnaires.

- Market sector and end-use categories were re-defined under more appropriate headings in 1985. (Note: because of these altered categories, direct comparisons between 1984 and prior years' data and subsequent years' data are difficult to make.)
- The term "manufacture" was defined to account for only outbound shipments, in contrast to actual manufacture, importation, or sales.

Modifications Affecting the "Annual Solar Thermal Collector Manufacturers Survey" (Form CE-63A):

- Information on metallic and nonmetallic low-temperature collectors was combined into one category.

- Information on medium-temperature liquid collectors was divided into three separate categories: thermosiphon, flat-plate (pumped), and integral collector storage (ICS).
- Questions were included to identify States to which shipments were made.
- Questions were included to identify States that received shipments.

Modifications Affecting the "Annual Photovoltaic Module Manufacturers Survey" (Form CE-63B):

- Questions were included regarding exports of modules versus cells.
- Questions were included regarding country of destination for exports of modules versus cells.

5. Survey Response

Manufacturers of Solar Thermal Collectors

The status of solar thermal collector manufacturers who were mailed survey forms for the 1988 survey is shown in Table 20. The 1988 survey responses to questionnaires sent to 78 potential solar collector manufacturers resulted in the following categories:

- Active companies: 50 questionnaires were returned by companies with shipments during this survey period.
- Inactive: 17 companies on the mailing list had no shipments in 1988 but were kept on the list because they may have shipments in future years.
- Out of business: 11 of the listed manufacturers were out of the solar manufacturing business during 1988 and have no plans to reenter the business in a future year.

Manufacturers of Photovoltaic Modules

The status of the photovoltaic module manufacturers who were mailed survey forms for the 1988 survey is shown in Table 21.

Table 20. Status of Solar Thermal Collector Manufacturers, 1988 Survey

Status	Number of Companies
Active	50
Inactive	17
Out of Business	11
Total	78

Source: Energy Information Administration, "Annual Solar Thermal Collector Manufacturers Survey," Form CE-63A, 1988.

Table 21. Status of Photovoltaic Module Manufacturers, 1988 Survey

Status	Number of Companies
Active	14
Inactive	0
Out of Business	5
Total	19

Source: Energy Information Administration, "Annual Photovoltaic Module Manufacturers Survey," Form CE-63B, 1988.

Appendix A

Survey Limitations, 1985

Appendix A

Survey Limitations, 1985

During 1986 the solar collector manufacturing industry experienced a substantial slowdown in shipments as a result of the expiration of the solar tax credit at the end of 1985 and the reduction in energy prices. Reported shipments declined from 16.4 million square feet in 1984 to 4.9 million square feet in 1986. Many of the 1986 shipments probably occurred during the first quarter, as customers took delivery of materials purchased in late 1985 when solar tax credits were still available. The following table presents the number of companies reporting and their reported shipments for the years 1984 through 1986.

Item	1984	1985*	1986
Number of Firms	224	116	97
Shipments (million square feet)	16.4	11.1	4.9

* Incomplete data.

Source: Energy Information Administration, "Annual Solar Thermal Collector Manufacturers Survey," Form EIA-63, 1984; Form CE-63A, 1985 and 1986.

Although reported shipments for 1985 were only 68 percent of those reported in 1984, it is likely that actual shipments were higher in 1985, which was believed to be a banner year because the energy tax credit expired at the end of the year. The number of firms reporting and, therefore, the reported shipments may have been low because many of the firms had gone out of business, and could not be located to collect the 1985 data when the data collection forms were mailed out more than 1 year later in early 1987. The following table presents the shipments only for the 80 firms that were in business all 3 years.

Item	1984	1985*	1986
Number of Firms	80	80	80
Shipments (million square feet)	8.7	9.9	4.6

* Incomplete data.

Source: Energy Information Administration, "Annual Solar Thermal Collector Manufacturers Survey," Form EIA-63, 1984; Form CE-63A, 1985 and 1986.

For the 80 firms that were in business all 3 of the years, shipments increased 14 percent in 1985 but decreased by 54 percent in 1986. Although it is not conclusive, this is an indication that if all the shipments for all firms in business in 1985 were reported, there would be a substantial increase from 1984 to 1985.

Appendix B

Survey Questionnaires and Instructions

Form CE-53A
U.S. DEPARTMENT OF ENERGY
Energy Information Administration

ANNUAL SOLAR THERMAL COLLECTOR MANUFACTURERS SURVEY

This report is mandatory under Public Laws 93-275 and 95-91. Late filing, failure to file, or failure otherwise to comply with these instructions may result in criminal fines, civil penalties, and other sanctions as provided by law. For information concerning confidentiality see the instructions.

Form Approved
OMB #: 1905-0172
Expires: 12/31/89

The reporting period for this survey is calendar year 198_____.

1.0 IDENTIFICATION DATA

1.1 Respondent identification

Complete (a) through (d) only if label is incorrect:

- (a) Company Name _____
(b) Street Address _____
(c) City _____
(d) State and ZIP Code _____

1.2 What are the name, title, and telephone number of a person in your company to whom questions may be addressed regarding this submission?

- (a) Name: _____ (c) Telephone _____
Area Code _____ Number _____
(b) Title: _____

2.0 MANUFACTURING STATUS (Please refer to the "Definition" Section for key words.)

2.1 During the current reporting period, did your company:

(Mark as appropriate)

- (a) Manufacture and ship solar energy collectors? ☐ Yes (a) ☐ No (b)
(b) Cease manufacturing but continue to ship solar energy collectors? ☐ Yes (a) ☐ No (b)
(c) Import and ship solar energy collectors? ☐ Yes (a) ☐ No (b)
(d) Manufacture and export solar energy collectors? ☐ Yes (a) ☐ No (b)

2.2 If you answered "No" to all parts of question 2.1, do you plan to manufacture, import, export, and ship solar collectors during the next 2 years?

- ☐ Yes (a) ☐ No (b)

Note: If you answered "Yes" to any part of question 2.1, please complete the remainder of this form.

If you answered "No" to all parts of question 2.1, please complete question 7.0 and return this form in the enclosed envelope or to the address specified in the instructions.

3.0 MANUFACTURER AND MARKETING DATA

3.1 Mark the appropriate box or boxes to indicate all the solar-related activities in which your company was engaged during this reporting period. Mark all that apply to your solar activities only.

- (a) ☐ Collector or system design
(b) ☐ Prototype collector development
(c) ☐ Prototype systems development
(d) ☐ Wholesale distribution
(e) ☐ Retail distribution
(f) ☐ Installation
(g) ☐ Manufacture of system-components other than those used for collector assembly
(h) ☐ Other (describe): _____

3.2 If you are expecting to introduce a new solar-related product in the next calendar year, please check the appropriate box.

- (a) ☐ Low-Temperature Collector
(b) ☐ Medium-Temperature Collector
(c) ☐ Special Collector
(d) ☐ Noncollector Solar System Components
(e) ☐ Other (describe): _____

3.3 In the box below, please enter the number of full-time-equivalent employees in your company that were engaged in solar-related activities during this reporting period. (For clarification of "full-time equivalent," see the instructions.)

3.4 What percentage of your company's total sales volume do solar-related activities compose?

- (a) ☐ 90 - 100%
(b) ☐ 50 - 89%
(c) ☐ 10 - 49%
(d) ☐ Less than 10%

Company Name: _____

Reporting Period (Calendar year 198)

4.0 SOLAR THERMAL COLLECTOR—DATA. For each type of collector manufactured or imported, and shipped, enter the data for this reporting period. If you did not provide EIA these data during the previous reporting period, but shipped collectors, please make a copy of this page and provide last year's data also.

ITEM	COLLECTOR TYPE								OTHER (specify) (h)	TOTAL (i)
	MEDIUM TEMPERATURE							SPECIAL Concentrator (g)		
	LOW TEMPERATURE (LIQUID AND AIR)	AIR	LIQUID				Evacuated tube (f)			
			Thermosiphon (c)	Flat plate (pumped) (d)	Integral collector storage (ICS) (e)					
	Metallic and nonmetallic (a)	All medium temperature (b)								
4.1 Grand total, collector shipments (square feet)										
4.2 Total value of collector shipments in 4.1 (dollars)										
4.3 Market sector (square feet)										
(1) Residential										
(2) - Commercial										
(3) Industrial										
(4) Utility										
(5) Other (describe)										
Total, market sector										
4.4 End use (square feet)										
(1) Pool heating										
(2) Hot water										
(3) Space heating										
(4) Combined space and water heating										
(5) Space cooling										
(6) Processing heating										
(7) Electricity generation										
(8) Other (describe)										
Total, end use										
4.5 Imports (square feet of total in 4.1)										
4.6 Exports (square feet of total in 4.1)										
4.7 List country(ies) of origin of imports in 4.5										
4.8 List country(ies) of destination for exports in 4.6										

5.0 GEOGRAPHIC DATA

5.1 Please place an "X" next to the State in which your company manufactured solar collectors and give the percentage (%) of your company's collectors manufactured in that State. If some collectors were imported from another country, please indicate the percentage under Code 00.

State Code	% Collectors Manufactured in the State	State Code	% Collectors Manufactured in the State	State Code	% Collectors Manufactured in the State
00	☐ Imported	18	☐ Kentucky	36	☐ Ohio
01	☐ Alaska	19	☐ Louisiana	37	☐ Oklahoma
02	☐ Alabama	20	☐ Maine	38	☐ Oregon
03	☐ Arizona	21	☐ Maryland	39	☐ Pennsylvania
04	☐ Arkansas	22	☐ Massachusetts	40	☐ Puerto Rico
05	☐ California	23	☐ Michigan	41	☐ Rhode Island
06	☐ Colorado	24	☐ Minnesota	42	☐ South Carolina
07	☐ Connecticut	25	☐ Mississippi	43	☐ South Dakota
08	☐ Delaware	26	☐ Missouri	44	☐ Tennessee
09	☐ D.C.	27	☐ Montana	45	☐ Texas
10	☐ Florida	28	☐ Nebraska	46	☐ Utah
11	☐ Georgia	29	☐ Nevada	47	☐ Vermont
12	☐ Hawaii	30	☐ New Hampshire	48	☐ Virgin Islands
13	☐ Idaho	31	☐ New Jersey	49	☐ Virginia
14	☐ Illinois	32	☐ New Mexico	50	☐ Washington
15	☐ Indiana	33	☐ New York	51	☐ West Virginia
16	☐ Iowa	34	☐ North Carolina	52	☐ Wisconsin
17	☐ Kansas	35	☐ North Dakota	53	☐ Wyoming

Total percentage _____ % (should amount to 100%)

5.2 Please place an "X" next to the State to which your company's collectors were shipped (including the State of collector manufacture) and give the percentage (%) of your company's collectors likely to have been shipped to that state. If some collectors were exported, please indicate the percentage under code 00.

State Code	% Collectors Shipped to the State	State Code	% Collectors Shipped to the State	State Code	% Collectors Shipped to the State
00	☐ Exported	18	☐ Kentucky	36	☐ Ohio
01	☐ Alaska	19	☐ Louisiana	37	☐ Oklahoma
02	☐ Alabama	20	☐ Maine	38	☐ Oregon
03	☐ Arizona	21	☐ Maryland	39	☐ Pennsylvania
04	☐ Arkansas	22	☐ Massachusetts	40	☐ Puerto Rico
05	☐ California	23	☐ Michigan	41	☐ Rhode Island
06	☐ Colorado	24	☐ Minnesota	42	☐ South Carolina
07	☐ Connecticut	25	☐ Mississippi	43	☐ South Dakota
08	☐ Delaware	26	☐ Missouri	44	☐ Tennessee
09	☐ D.C.	27	☐ Montana	45	☐ Texas
10	☐ Florida	28	☐ Nebraska	46	☐ Utah
11	☐ Georgia	29	☐ Nevada	47	☐ Vermont
12	☐ Hawaii	30	☐ New Hampshire	48	☐ Virgin Islands
13	☐ Idaho	31	☐ New Jersey	49	☐ Virginia
14	☐ Illinois	32	☐ New Mexico	50	☐ Washington
15	☐ Indiana	33	☐ New York	51	☐ West Virginia
16	☐ Iowa	34	☐ North Carolina	52	☐ Wisconsin
17	☐ Kansas	35	☐ North Dakota	53	☐ Wyoming

Total percentage _____ % (should amount to 100%)

6.0 PUBLICATION DATA

6.1 Do you want the name and address of your company to appear in the appendix of the next Solar Collector Manufacturing Activity report? ☐ Yes (a) ☐ No (b)

6.2 Do you want to receive a copy of the next Solar Collector Manufacturing Activity report? ☐ Yes (a) ☐ No (b)

7.0 CERTIFICATION

I certify that the information contained and appended is true and accurate to the best of my knowledge.

Name: _____ Title: _____

Signature: _____ Date: _____

Enter any additional remarks here. _____

**INSTRUCTIONS FOR
FORM CE-63A, ANNUAL SOLAR THERMAL COLLECTOR MANUFACTURERS SURVEY
GENERAL INFORMATION AND INSTRUCTIONS**

I. Purpose

Form CE-63A is designed to provide the data necessary for the Energy Information Administration (EIA) in the Department of Energy (DOE) to carry out its responsibilities for tracking certain volumetric movements in the solar collector manufacturing industry and for providing information concerning the size and status of the industry. The publication *Solar Collector Manufacturing Activity* will contain the results of this survey.

II. Who should respond to this survey

Form CE-63A is to be submitted by (1) all companies that manufactured and shipped (including exporting) solar thermal collectors and (2) companies that imported solar thermal collectors during the reporting period.

III. Where to submit completed forms

Companies should return completed CE-63A forms to:

Energy Information Administration, EI-531
Mail Station: BG-094-Forrestal
U.S. Department of Energy
Attn: CE-63 A
Washington, D.C. 20585

Requests for further information and/or additional forms may be mailed to the above address or telephoned to the survey project manager at (202) 586-9775.

IV. When to submit completed forms

Completed CE-63A forms are due on the date specified in the cover letter. The reporting period is from January 1 through December 31.

V. Sanctions

This report is mandatory and is being required pursuant to the authority granted to DOE by the Federal Energy Administration Act of 1974 (Public Law 93-275) and the Department of Energy Organization Act (Public Law 95-91).

VI. Provisions regarding confidentiality

Information on this form is being collected for statistical purposes and will not be published by DOE in individually identifiable form. However, upon receiving a request for individually identifiable information, DOE will follow the procedures listed below.

- a. The information contained in Form CE-63A will be kept confidential to the extent that it satisfies the criteria set forth in the Freedom of Information Act (FOIA) exemption for trade secrets and confidential commercial information and DOE regulations implementing the FOIA, and is prohibited from public release by the Trade Secrets Act, 18 U.S.C. § 1905. Upon receiving a request for disclosure of this information under the FOIA, DOE shall, in accordance with the procedures and criteria provided in 10 C.F.R. § 1004.11, make a final determination whether the information is exempt from disclosure. To assist us in this determination, respondents should demonstrate to DOE that their information constitutes trade secrets or commercial or financial information whose release would be likely to cause substantial harm to the company's competitive position. A letter accompanying the submission, explaining (on an element-by-element basis, if possible) why the information would be likely to cause the respondent substantial competitive harm if released to the public, would assist DOE in this determination. No new justification has to be provided each time the company submits a form unless the company either (1) has not previously submitted a justification for that information or (2) has changed the basis for justification.
- b. Requests from other Federal agencies for information from this form shall be evaluated in accordance with the DOE Policy on the Disclosure of Individually Identifiable Energy Information in the Possession of the EIA [45 Federal Register 59812 (1980)].
- c. Except as otherwise provided by law, the information will also be made available in response to an order of a Court of competent jurisdiction, or upon written request, to Congress, any Committee of Congress, the General Accounting Office, or other congressional agencies that are authorized by law to receive such information.

DEFINITIONS

1. Air Collector — A medium-temperature collector used predominantly in space heating, utilizing pumped air as the heat-transfer medium.
2. Concentrator — A reflective or refractive solar thermal collector that focuses solar rays onto an area smaller than the reflective or refractive surface, resulting in higher intensity solar rays at the point of focus.
3. Evacuated Tube — In a solar thermal collector, an absorber tube, contained in an evacuated glass cylinder, through which collector fluid flows.
4. Exports — Solar collectors only, manufactured in the United States and shipped to another country.
5. Flat Plate (Pumped) — Medium-temperature liquid collectors, which typically utilize a metal frame, glazing, absorbers (usually metal), and insulation, and use pumped liquid as the heat transfer medium; predominantly used in water heating applications.
6. Imports — Solar collectors only, manufactured outside of the United States and shipped into the United States.
7. Integral Collector Storage (ICS) — Collectors in which solar radiation is absorbed directly by the storage medium.
8. Low-Temperature Collectors — Metallic or nonmetallic collectors that generally operate at temperatures below 110° F and use pumped liquid or air as the heat transfer medium. They usually contain no glazing and no insulation, and they are often made of plastic or rubber, although some are made of metal.
9. Medium-Temperature Collectors — Collectors that generally operate in the temperature range of 140° F to 180° F but can also operate at a temperature as low as 110° F. The collectors are typically made of a metal frame, metal absorption panels with integral flow channels or attached tubing (liquid collectors) or with integral ducting (air collectors), and glazing and insulation on the sides and back.
10. Metallic — The metallic material composition of the collector's absorber system.
11. Special Collector — Less conventional collectors such as evacuated tube, concentrators, and other types used primarily in high-temperature applications such as air conditioning and industrial processes.

SPECIFIC INSTRUCTIONS

Specific instructions for most items are provided below. Self-explanatory items are not discussed.

Item	Instruction
1.1 (a)-(d)	Make corrections to the company name or address in the space provided.
1.2 (a)-(c)	Enter the name, title, and telephone number of an individual in the reporting company who may be contacted for additional information regarding this submission.
3.1 (a)-(h)	Report only on activities that are solar related.
3.2 (a)-(e)	A new solar-related product is differentiated from a modified existing product if the "new" product is different enough to warrant a new model number and requires retesting or recertification under existing industry standards.
3.3	"Full-time-equivalent" is defined as salaried employee time of at least 1,600 hours per year. Combined time of part-time solar-related employees meets the definition. Round to the nearest digit.
3.4	"Solar-related activities" includes all activities listed in question 3.1.
4.1	Enter the square footage (not the number of collectors), in whole numbers (i.e., no decimals), of solar collectors shipped for final consumption or to another organization for resale (including exports and imports) in the appropriate collector type column. Total (column I) should be the total square feet of all collector types in that row.
4.2	The value reported should be total value received for the collectors only, at your company's net billing price, freight-on-board factory, including charges for cooperative advertising and warranties. Do not include excise taxes, freight, or transportation. Report values to the nearest dollar.
4.3	For each appropriate sector, enter the square footage of collector shipments, by collector type, as precisely as possible. For market-sector categories in question 4.3:
	Part (1) <i>Residential</i> — Solar applications related to any building used for residential occupancy that has a system for heating or cooling, or both.
	Part (2) <i>Commercial</i> — Solar applications for use in businesses where services (rather than products) are provided, such as wholesale and retail trade or health and educational services.
	Part (3) <i>Industrial</i> — Solar applications for use in businesses where products (rather than services) are provided, such as the manufacture and processing of goods and basic materials.
	Part (4) <i>Utility</i> — Shipments of solar collectors to utilities for use in power generation or for experimental applications. (Includes gas and electric utilities.)
	Part (5) Self-explanatory.
	Part (6) Total should be the same total square footage of all collector types as was entered in 4.1.
4.4	For each end use, enter the square footage of collector shipments, by collector type, as precisely as possible. For each end-use category in question 4.4:
	Part (1) through Part (4) Self-explanatory.
	Part (5) If collectors are used for space cooling, or for space cooling in combination with water and/or space heating, enter the total square footage.
4.5	Enter the square footage by collector type. This represents the portion of total collector shipments entered in 4.1 that were imported and shipped by your firm.
4.6	Enter the square footage by collector type. This represents the portion of total collector shipments entered in 4.1 that were manufactured for export and shipped (sold) to another country.
4.7	Enter the country(ies) from which solar collectors reported in question 4.5 were imported.
4.8	Enter the country(ies) to which solar collectors reported in question 4.6 were exported.
5.1	Please identify only the State of final assembly of the collector. Please be certain to provide total percentage calculations.
5.2	Refers to collector shipments only. Indicate the last State of destination of which you are aware.

U.S. G.P.O. 1987-191-150/40285

Form CE-63B
U.S. DEPARTMENT OF ENERGY
Energy Information Administration

ANNUAL PHOTOVOLTAIC MODULE MANUFACTURERS SURVEY

This report is mandatory under Public Laws 93-275 and 95-61. Late filing, failure to file, or failure otherwise to comply with these instructions may result in criminal fines, civil penalties, and other sanctions as provided by law. For information concerning confidentiality, see the instructions.

Form Approved
OMB # 1905-0172
Expires: 12/31/89

The reporting period for this survey is calendar year 198_____.

1.0 IDENTIFICATION DATA

1.1 Respondent Identification

Complete (a) through (d) only if label is incorrect

- (a) Company Name _____
(b) Street Address _____
(c) City _____
(d) State and ZIP Code _____

1.2 What are the name, title, and telephone number of a person in your company to whom questions may be addressed regarding this submission?

- (a) Name: _____ (c) Telephone _____
Area Code _____ Number _____
(b) Title: _____

2.0 MANUFACTURING STATUS (Please refer to the "Definition" section for key words.)

- 2.1 During the current reporting period, did your company: (Mark as appropriate)
- | | | |
|--|----------------------------------|---------------------------------|
| (a) Manufacture and ship photovoltaic modules? | ☐ Yes (a) | ☐ No (b) |
| (b) Cease manufacturing but continue to ship photovoltaic modules? | ☐ Yes (a) | ☐ No (b) |
| (c) Import and ship photovoltaic modules? | ☐ Yes (a) | ☐ No (b) |
| (d) Manufacture and export photovoltaic modules? | ☐ Yes (a) | ☐ No (b) |
- 2.2 If you answered "No" to all parts of question 2.1, do you plan to manufacture, import, export, and ship photovoltaic modules during the next 2 years? ☐ Yes (a) ☐ No (b)

Note: If you answered "Yes" to any part of question 2.1, please complete the remainder of this form.

If you answered "No" to all parts of question 2.1, please complete question 6.0 and return this form in the enclosed envelope or to the address specified in the instructions.

3.0 MANUFACTURER AND MARKETING DATA

3.1 Mark the appropriate box or boxes to indicate all the photovoltaic-related activities in which your company was engaged in during this reporting period. Mark all that apply to your photovoltaic activities only.

- (a) ☐ Module or system design
(b) ☐ Prototype module development
(c) ☐ Prototype systems development
(d) ☐ Wholesale distribution of modules
(e) ☐ Retail distribution of modules
(f) ☐ Installation
(g) ☐ Manufacture of system components other than those used for module assembly
(h) ☐ Other (describe): _____

3.2 If you are expecting to introduce new photovoltaic-related products in the next calendar year, please check the appropriate box(es).

- (a) ☐ Single-crystal silicon modules
(b) ☐ Cast silicon modules
(c) ☐ Ribbon silicon modules
(d) ☐ Amorphous silicon modules
(e) ☐ Other (flat plate)—specify: _____
(f) ☐ Other (concentrator)—specify: _____
(g) ☐ Nonmodule system components—specify: _____

3.3 In the box below, please enter the number of full-time-equivalent employees in your company that were engaged in photovoltaic-related activities during this reporting period. (For clarification of "full-time equivalent," see the instructions.)

Company Name: _____

Reporting Period (Calendar year 198): _____

4.0 PHOTOVOLTAIC MODULES—DATA. For each type of module manufactured or imported, and shipped, enter the data for this reporting period. If you did not provide EIA these data during the previous reporting period, but shipped modules, please make a copy of this page and provide last year's data also.

ITEM	MODULE TYPE							OTHER (specify)	TOTAL
	CRYSTALLINE SILICON			THIN FILM					
	Single-Crystal (Czochralsky)	Cast	Ribbon	Amorphous silicon	CONCENTRATOR		Gallium arsenide		
					Silicon				
4.1 Grand total net module shipment (kW)									
4.2 Total value of shipments in 4.1 (dollars)									
4.3 End use (in kW)									
(1) Space applications									
(2) Water pumping									
(3) Transportation									
(4) Communication									
(5) Consumer goods									
(6) Military									
(7) Residential									
(8) Industrial/Commercial									
(9) Utility									
(10) Other uses: (specify) _____									
Total end use (in kW)									
4.4 Module imports (kW)									
4.5 Exports: (kW)									
(1) Modules									
(2) Cells									
4.6 List country(ies) of origin of imports in 4.4									
4.7 List country(ies) of destination for exports in 4.5									
(1) Modules									
(2) Cells									

5.0 PUBLICATION DATA

- 5.1 Do you want the name and address of your company to appear in the appendix of the next Solar Collector Manufacturing Activity report? ☐ Yes (a) ☐ No (b)
- 5.2 Do you want to receive a copy of the next Solar Collector Manufacturing Activity report? ☐ Yes (a) ☐ No (b)
-

6.0 CERTIFICATION

I certify that the information contained and appended is true and accurate to the best of my knowledge.

Name: _____ Title: _____

Signature: _____ Date: _____

Enter any additional remarks here. _____

INSTRUCTIONS FOR
FORM CE-63B, ANNUAL PHOTOVOLTAIC MODULE MANUFACTURERS SURVEY
GENERAL INFORMATION AND INSTRUCTIONS

I. Purpose

Form CE-63B is designed to provide the data necessary for the Energy Information Administration (EIA) in the Department of Energy (DOE) to carry out its responsibilities for tracking certain volumetric movements in the photovoltaic module manufacturing industry and for providing information concerning the size and status of the industry. The publication *Solar Collector Manufacturing Activity* will contain the results of this survey.

II. Who should respond to this survey

Form CE-63B is to be submitted by (1) all companies that manufactured and shipped (including exporting) photovoltaic modules and (2) companies that imported photovoltaic modules during the reporting period.

III. Where to submit completed forms

Companies should return completed CE-63B forms to:

Energy Information Administration, EI-531
Mail Station: BG-094-Forrestal
U.S. Department of Energy
Attn: CE-63 B
Washington, D.C. 20585

Requests for further information and/or additional forms may be mailed to the above address or telephoned to the survey project manager at (202) 586-9775.

IV. When to submit completed forms

Completed CE-63B forms are due on the date specified in the cover letter. The reporting period is from January 1 through December 31.

V. Sanctions

This report is mandatory and is being required pursuant to the authority granted to DOE by the Federal Energy Administration Act of 1974 (Public Law 93-275) and the Department of Energy Organization Act (Public Law 95-91).

VI. Provisions regarding confidentiality

Information on this form is being collected for statistical purposes and will not be published by DOE in individually identifiable form. However, upon receiving a request for individually identifiable information, DOE will follow the procedures listed below.

- a. The information contained in Form CE-63B will be kept confidential to the extent that it satisfies the criteria set forth in the Freedom of Information Act (FOIA) exemption for trade secrets and confidential commercial information and DOE regulations implementing the FOIA, and is prohibited from public release by the Trade Secrets Act, 18 U.S.C. § 1905. Upon receiving a request for disclosure of this information under the FOIA, DOE shall, in accordance with the procedures and criteria provided in 10 C.F.R. § 1004.11, make a final determination whether the information is exempt from disclosure. To assist us in this determination, respondents should demonstrate to DOE that their information constitutes trade secrets or commercial or financial information whose release would be likely to cause substantial harm to the company's competitive position. A letter accompanying the submission, explaining (on an element-by-element basis, if possible) why the information would be likely to cause the respondent substantial competitive harm if released to the public, would assist DOE in this determination. No new justification has to be provided each time the company submits a form unless the company either (1) has not previously submitted a justification for that information or (2) has changed the basis for justification.
- b. Requests from other Federal agencies for information from this form shall be evaluated in accordance with the DOE Policy on the Disclosure of Individually Identifiable Energy Information in the Possession of the EIA [45 Federal Register 59512 (1980)].
- c. Except as otherwise provided by law, the information will also be made available in response to an order of a Court of competent jurisdiction, or upon written request, to Congress, any Committee of Congress, the General Accounting Office, or other congressional agencies that are authorized by law to receive such information.

DEFINITIONS

1. Amorphous Silicon — Thin layers of noncrystalline material, primarily silicon based, deposited onto a metallic or nonmetallic surface, that compose a module.
2. Cast Silicon — Polycrystalline silicon cells, derived by various techniques, that compose a module. Cells referred to as semicrystalline are included.
3. Cells — Refers to the un-encapsulated semiconductor components of the module which convert the solar energy to electricity. Incomplete cells, those requiring further processing, are not considered. Cells are differentiated from modules only in Questions 4.5 and 4.7 when referring to exports.
4. Communication — Photovoltaic modules employed to power fixed base telecommunications equipment, such as mountain top repeater stations.
5. Concentrator — Reflective or refractive photovoltaic module that focuses solar rays onto an area smaller than the reflective or refractive surface, thus increasing the intensity of the solar rays at the point of focus. (Report on module kW not cell kW.)
6. Consumer Goods — Photovoltaic modules (sometimes in cell forms) used to power consumer goods such as portable radios, toys, watches, calculators, small battery chargers, etc. (Please specify on the bases of stabilized full sun rating.)
7. Exports — Photovoltaic modules and cells manufactured in the United States and shipped to another country.
8. Imports — Photovoltaic modules only, manufactured outside of the United States and shipped into the United States from another country.
9. Industrial Commercial — Photovoltaic modules employed to produce power for large commercial (i.e., hospitals, office buildings, schools, etc.) and industrial applications. Includes both grid and non-grid connected systems. Excludes uses specified in questions 4.3 (1) through (7).
10. Military — Photovoltaic modules shipped to any branch of the U.S. military. Also includes shipments for military applications by foreign governments. Excludes modules already accounted for in questions 4.3 (1) through (5).
11. Modules — Photovoltaic cells or an assembly of cells into panels (modules) intended for and shipped for final consumption, or to another organization for resale. When exported, incomplete modules and un-encapsulated cells are also included.
12. Net Module Shipments — Represents the difference between module (as defined above) shipments and module purchases. When exported incomplete modules and un-encapsulated cells are also included.
13. Residential — Photovoltaic modules that are used in distributed, grid connected or non-grid connected photovoltaic systems to provide power for residential applications.
14. Ribbon Silicon — Single-crystal silicon derived by means of fabricating processes that produce sheets or ribbons of single-crystal silicon. These processes include: edge-defined film-fed growth (EFG), dendritic web growth, and ribbon-to-ribbon growth (RTR).
15. Silicon — A semiconductor material made from silica, purified for photovoltaic applications.
16. Single-Crystal Silicon (Czochralsky) — Silicon cells with a well-ordered crystalline structure consisting of one crystal (usually obtained by means of the Czochralsky growth technique and involving ingot slicing), composing a module. Ribbon silicon (as defined above) is excluded.
17. Space Applications — Photovoltaic modules used for non-terrestrial applications, such as satellites, space stations, etc. Please specify shipments in kW on the basis of typical operating conditions, including air mass zero.
18. Transportation — Photovoltaic modules used on boats, cars, and recreational vehicles; and those used for transportation support systems such as signs, illumination, warning signals, etc.
19. Utility — Photovoltaic modules used to produce power at a utility owned system including central stations, decentralized systems or experimental applications.
20. Water Pumping — Photovoltaic modules used for pumping water for agricultural, land reclamation, commercial and other similar applications where water pumping is the main use.

SPECIFIC INSTRUCTIONS

Specific instructions for most items are provided below. Self-explanatory items are not discussed.

<u>Item</u>	<u>Instruction</u>
1.2 (a)-(c)	Enter the name, title, and telephone number of an individual in the reporting company who may be contacted for additional information regarding this submission.
3.1 (a)-(h)	Report only on activities that are photovoltaic related.
3.2 (a)-(g)	A new photovoltaic product is differentiated from a modified existing product if the "new" product is different enough to warrant a new model number and requires retesting or recertification under existing industry standards.
3.3	"Full-time-equivalent" is defined as salaried employee time of at least 1,800 hours per year. Combined time of part-time employees meets the definition. Round to the nearest digit.
4.1	Enter the peak kilowatt value of photovoltaic modules shipped (including exports and imports) in the appropriate module type column. Total should be the total peak kilowatts of all module types. Concentrator modules shipments must be expressed in module kW not cell kW.
4.2	The value reported should be total value received for the modules only, at your company's net billing price, freight-on-board factory, including charges for cooperative advertising and warranties. Do not include excise taxes, freight, or transportation. Report values to the nearest dollar.
4.3	For each end-use category in questions 4.3 (1-10), enter the peak kilowatts of producer shipments, by module type.
4.4	Enter the peak kilowatts by module type. This amount represents the portion of total producer shipments entered in 4.1 that were imported and shipped.
4.5	Enter the peak kilowatts by module type. This amount represents the portion of total producer shipments entered in 4.1 that were exported. Report modules in 4.5 (1) and cells in 4.5 (2).
4.6	List the country(ies) from which photovoltaic modules reported in question 4.4 were imported.
4.7	List the country(ies) to which photovoltaic modules and cells reported in question 4.5 were exported. List countries of destination for modules in 4.7 (1) and list countries of destination for cells in 4.7 (2).

Appendix C

Respondents to the Annual Solar Manufacturers Survey

Respondents to the Annual Solar Thermal Collector Manufacturers Survey

1. Solar Energy Systems, Inc.
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58. Solar Energy Systems, Inc.
59. Solar Energy Systems, Inc.
60. Solar Energy Systems, Inc.

Appendix C

Respondents to the Annual Solar Thermal Collector Manufacturers Survey

Acorn Structures Inc.³
P.O. Box 250
Concord, Massachusetts 01742

American Energy Technology
P.O. Box 1865
Green Cove Springs, Florida 32043

Applied Solar Products
4580-A Almaden Expressway
San Jose, California 95118

Astron Technologies, Inc.
3901 Atlantic Avenue
Raleigh, North Carolina 27604

Contemporary Systems, Inc.
Rt. 12
Walpole, New Hampshire 03608

Coyne Solar Company
Box 1120
San Juan Pueblo, New Mexico 87566

Elbart Manufacturing Company
127 West Main
Millbury, Massachusetts 01527

Equinox Solar, Inc.
3501 N.W. 60th Street
Miami, Florida 33142

FAFCO
255 Constitution Avenue
Menlo Park, California 94025

GS Energy Industries, Inc.
108 Jefferson Avenue
Des Moines, Iowa 50314

Haleakala Resources
250 Ala Maha Place
Suite 6
Kahului, Maui, Hawaii 96732

Hanson Energy Products
River Road
Newcastle, Maine 04553

Heliocol U.S.A., Inc.
210 Crown Point Drive
Longwood, Florida 32779

Heliodyne Corporation
4910 Seaport Avenue
Richmond, California 94804

Maine Solartechnics
360 Center Street
Bangor, Maine 04401

Northern Solar Power Co.
311 South Elm Street
Moorhead, Minnesota 56560

Progressivtube Manufacturing Corp.
P.O. Box 3887
Sarasota, Florida 34230

RADCO Products, Inc.
2877 Industrial Parkway
Santa Maria, California 93455

Ramada Energy Systems, Ltd.
1421 South McClintock
Tempe, Arizona 85281

S & L Solar Systems
Apartado 1535
Carolina, Puerto Rico 00630

³Note: Only those respondents requesting inclusion of their names and addresses are listed in this Appendix.

Science Applications International Corporation
10401 Roselle Street
San Diego, California 92121

Sealed Air Corporation
3433 Arden Road
Hayward, California 94545

Solahart U.S.A.
11855 Sorrento Valley Road
San Diego, California 92121

Solar Alternative Inc.
P.O. Box 739
Brattleboro, Vermont 05301

Solar Components Corporation
88 Pine Street
Manchester, New Hampshire 03105

Solar Development, Inc.
3630 Reese Avenue
Riviera Beach, Florida 33404

Solar Energy & Resources, Inc.
P.O. Box 2929
Bayamon, Puerto Rico 00621

Solar Eye Products, Inc.
1300 N.W. McNab Road Building
Ft. Lauderdale, Florida 33309

Solar Living, Inc.
P.O. Box 12
Netcong, New Jersey 07857

Solar Research Division, RR. Inc.
P.O. Box 869
Brighton, Michigan 48116

Solar Services, Inc.
G.P.O. Box 3727
San Juan, Puerto Rico 00936

Solar Trek, Inc.
3700 S.W. 7th Street
Ocala, Florida 32674

Solar Water Heaters of NPR, Inc.
7117 U.S. 19
New Port Richey, Florida 33552

Solar Wind Energy Development Co.
Box 617, Johnson Road
Warsau, Kentucky 41095

Southwest Ener-Tech, Inc.
3030 S. Valley View Blvd.
Las Vegas, Nevada 89102

Sun Glow Systems
P.O. Box 18324
Fountain Hills, Arizona 85268

Sunmaster Corporation
911 Addison Road, Rt. 1
Painted Post, New York 14870

Sunwatt Corporation
RR 2, Box 63
English, Indiana 04606

UNICO Manufacturing
1432 Plum Street
Raton, New Mexico 87740

U.S. Solar Corporation
County Road 325
P.O. Drawer K
Hampton, Florida 32044

Universal Solar Products, Inc.
Avenida Roosevelt 1108 Puerto Nuevo
San Juan, Puerto Rico 00920

Virginia Solar Components, Inc.
Route 4, Highway 29 S.
Rustburg, Virginia 24588

Appendix D

Respondents to the Annual Photovoltaic Module Manufacturers Survey

Appendix D

Respondents to the Annual Photovoltaic Module Manufacturers Survey

ARCO Solar, Inc.⁴
4530 Adhor Lane
Camarillo, California 93010

CHRONAR
P.O. Box 177
Princeton, New Jersey, 08542

ENTECH, Inc.
P.O. Box 612246
Dallas/Ft. Worth Airport, Texas 75261

KYOCERS America, Inc.
8611 Balboa Avenue
San Diego, California 92123

Mobil Solar Energy Corporation
4 Suburban Park Drive
Billerica, Massachusetts 08121

Solec International
12533 Chadron Avenue
Hawthorne, California 90250

Sovonics Solar Systems
1100 W. Maple Road
Troy, Michigan 48084

Sunwatt Corporation
RFD Box 751
Addison, Maine 04606

Utility Power Group
9410 Desoto Avenue
Unit G
Chatsworth, California 91311

Westinghouse Electric Corporation
Advanced Energy Systems Division
P.O. Box 10864
Pittsburgh, Pennsylvania 15236

⁴Note: Only those respondents requesting inclusion of their names and addresses are listed in this Appendix.

Glossary

Concentrator: A reflective or refractive device that focuses solar rays onto an area smaller than the reflective or refractive surface, resulting in higher intensity solar rays at the point of focus.

Evacuated-Tube Collector: A solar thermal collector in which the collector fluid flows through an absorber tube that is contained inside an evacuated glass cylinder.

Low-Temperature Collector: A collector that generally operates in the temperature range below 110 degrees Fahrenheit. Typically, it has no glazing or insulation and is made of plastic or rubber, although some are made of metal.

Medium-Temperature Collector: A collector that generally operates in the temperature range of 140 to 180 degrees Fahrenheit, but may operate at temperatures as low as 110 degrees Fahrenheit. Typically, it has one or two glazings, a metal frame, a metal absorption panel with integral flow channels or attached tubing (liquid collector) or with integral ducting (air collector), and insulation on the sides and back of the panel.

One Sun: Natural solar insulation falling on an object without concentration or diffusion of the solar rays.

Photovoltaic Module: A group of photovoltaic cells. (Cells are solid-state devices used primarily in applications requiring remote power, such as radio communication, cathodic protection, and navigational aids.)

Solar Thermal Collector: A device designed to receive solar radiation and convert it into thermal energy. Normally a solar thermal collector includes a frame, glazing, and an absorber together with appropriate insulation. The heat collected by the solar thermal collector may be used immediately or stored for later use. Water or water/antifreeze solutions are the most common working media for transferring heat from the collector. Air and special oils that operate at high temperatures are also used in many systems. Pool covers and other devices that do not involve the transport of energy via a working medium are not considered to be solar thermal collectors for the purpose of this survey.

Special Collector: An evacuated tube collector or a concentrating (focusing) collector. Special collectors operate in the temperature range from just above ambient temperature (low concentration for pool heating) to several hundred degrees Fahrenheit (high concentration for air conditioning and specialized industrial processes).

Survey Frame: The list of potential manufacturers of solar collectors or photovoltaic modules to which survey forms are sent.

Thermosiphon System: A solar collector system for water heating in which circulation of the collection fluid through the storage loop is provided solely by the temperature and density difference between the hot and cold fluids.

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